Z·ONA4LIFE

Filling Sustainability Policy Gaps in the EU context:

a Critical Analysis of Zeolite Synthesis from Waste

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Disclaimer

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Introduction

The present Blueprint draws on insights from the EU-funded Z-ONA4LIFE project, an initiative focused on the sustainable production and recycling of aluminium salt slag in Spain and across Europe.The data were gathered through exchanges with experts in the form of a workshop and an open consultation, which have highlighted the critical role of synthetic zeolites in advancing circular economy practices, particularly in sectors such as catalysis, environmental remediation, and agriculture.

Zeolites, known for their versatile applications and sustainable benefits, are central to the project's goals of reducing dependency on raw materials and promoting innovative recycling technologies. The Z-ONA4LIFE project specifically focuses on fostering a market for synthetic zeolites, starting in Spain and expanding throughout Europe, by leveraging industrial by-products, thereby aligning with the European Union's Green Deal and Circular Economy Action Plan. This blueprint synthesises the data gathered, and provides preliminary recommendations aimed at closing key policy gaps that hinder the full adoption of waste-based zeolite at an industrial scale.

Context and state of the art

In the EU context, several regulations have been passed over the last years targeting sustainability and critical raw materials recycling to ensure the promotion of sustainable practices and adherence to Green Deal principles.

- Sustainable Development Goals (SDGs) (Adopted in 2015) : the EU aligns with the United Nations Sustainable Development Goals (SDGs) to address global challenges such as poverty, climate change, and inequality. A key focus within this alignment is the sustainable management of natural resources, including raw materials, and promoting circular economy principles such as recycling and reuse. These efforts aim to reduce resource depletion, minimise waste, and foster innovation in recycling technologies, thereby supporting sustainable economic growth and mitigating environmental impact. These goals are integrated into EU policies to promote sustainable economic growth and take climate action. Regular monitoring ensures the alignment of national and EU-level strategies with these goals[1].
- Waste Framework Directive (Originally passed in November 2008, updated periodically) : the Waste Framework Directive sets the groundwork for waste management in the EU, emphasising the prevention, reuse, and recycling of waste. Recent updates focus on fostering a circular economy and encouraging sustainable waste management practices, with extended producer responsibility (EPR) as a key component to ensure manufacturers play a role in managing product waste[2].
- European Green Deal (December 2019) : the European Green Deal aims to make the EU climate-neutral by 2050. It integrates various strategies to decouple economic growth from resource use, reduce greenhouse gas emissions, and promote sustainability across multiple sectors, such as energy, agriculture, and industry. It also ensures a fair and inclusive transition to a green economy[3].
- Circular Economy Action Plan (March 2020) : this action plan is a core component of the European Green Deal. It promotes sustainable product design, waste prevention, and the reduction of resource use in key sectors like electronics, textiles, and plastics. The plan includes initiatives such as the “Right to Repair” to extend product life and restrict single-use products[4].
- Chemicals Strategy for Sustainability (CSS) (October 2020) : part of the European Green Deal, the CSS seeks to minimise the environmental and health impacts of chemical production. It encourages innovation for safer alternatives and promotes the elimination of harmful chemicals from products. The strategy also supports non-toxic material cycles for a circular economy.
- EU Chemical Strategy (October 2020) : complementing the CSS, the EU Chemical Strategy focuses on improving chemical safety by minimising exposure to hazardous substances. It encourages the use of sustainable and safer chemicals, enhancing traceability and labelling standards to promote transparency and consumer safety[5].
- EU Industry Strategy (Updated in May 2021) : the revised EU Industry Strategy was developed to boost Europe’s economic recovery post-COVID-19, with a focus on strengthening supply chains, supporting SMEs, and promoting sustainable and digital transitions. It aims to maintain the EU’s competitiveness while aligning with climate-neutrality goals set out in the Green Deal[6].
- EU Standardisation Strategy (February 2022) : Under theEU Standardisation Strategy, efforts to promote standards that can facilitate the EU’s critical infrastructures and technologies development are encouraged to guarantee competitiveness and innovation for green and digital transitions. As such, part of the strategy focuses on key areas such as critical raw materials recycling, circular economy principles, and digital infrastructure, ensuring that European industries remain competitive while contributing to sustainability goals[7].

1. https://commission.europa.eu/strategy-and-policy/sustainable-development-goals_en
2. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en
3. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en
4. https://ec.europa.eu/newsroom/growth/items/673419/en
5. https://environment.ec.europa.eu/strategy/chemicals-strategy_en
6. https://single-market-economy.ec.europa.eu/industry/strategy_en
7. https://single-market-economy.ec.europa.eu/single-market/european-standards/standardisation-policy/standardisation-strategy_en

In the Spanish context, tailored regional policies have aligned to the EU context, with a focus on reducing waste, promoting resource efficiency, and fostering innovation in sustainable business models to guarantee compliance and implementation at national level.

- Law 7/2022 on Waste and Contaminated Soils for a Circular Economy (Ley de residuos y suelos contaminados para una economía circular), was enacted in Spain on April 8, 2022. It addresses waste management and aims to promote sustainability through a circular economy model, focusing on waste reduction, resource efficiency, and environmental protection. The law aligns with European Union directives and Spain's environmental policies. The key points of Ley 7/2022 are the waste hierarchy and circular economy, the single-use plastics ban, the producer responsibility, the waste reduction targets, the taxation on waste, remediation and management of contaminated soils, and public awareness and education
- Spanish Circular Economy Strategy (España Circular 2030) (2020) : launched in 2020, the España Circular 2030 strategy serves as Spain's national roadmap to transition toward a more sustainable and resource-efficient economy. The strategy sets ambitious targets to reduce waste generation by 15% and decrease greenhouse gas emissions related to waste management by 10% by 2030. España Circular 2030 is closely aligned with the EU's Circular Economy Action Plan and serves as the foundation for regional initiatives and sector-specific strategies that focus on achieving these goals[8].
- Circular Economy Strategy of the Principality of Asturias (Estrategia de Economía Circular del Principado de Asturias 2023-2030): this strategy is a regional plan aimed at transitioning Asturias toward a more sustainable, resource-efficient economic model. The strategy aligns with the broader goals of Spain and the European Union for a circular economy, which focuses on reducing waste, extending the lifecycle of products, and promoting recycling and reuse. Thus, this strategy outlines a roadmap for transforming the economy of Asturias into a more sustainable model by prioritising resource efficiency, reducing waste, and fostering innovation, while also supporting industrial renewal and creating new job opportunities in green sectors[9].
- Circular Economy Basque Strategy 2030 (2020) : the Basque Country is a leading region in Spain's transition to a circular economy, with the Circular Economy Basque Strategy 2030 serving as a model for regional efforts to promote sustainability. This regional strategy is a key component of the Basque Government's broader climate and economic policies, focusing on reducing material consumption by 30% and waste generation by 10% by 2030. The strategy places a strong emphasis on ecodesign and the integration of circularity principles in manufacturing and construction. It also encourages public-private partnerships to foster innovation and promote circular economy practices across industries[10].
- National Programme for the Prevention of Waste (Plan Nacional Integrado de Residuos) (Updated 2021) : the National Programme for the Prevention of Waste is a central part of Spain's efforts to reduce waste at the source and promote sustainable consumption and production. The program, updated in 2021, sets goals to reduce waste generation across various sectors, focusing particularly on household waste, construction, and packaging. This programme aligns with Spain's broader Circular Economy Strategy and European waste prevention policies, aiming to enhance resource efficiency and reduce Spain's dependence on raw materials[11].

The existing regulatory framework in the EU and Spain, as discussed above, demonstrates a focus on sustainable resource management and the promotion of recycling to reduce dependency on raw materials. These policies lay the groundwork for advancing innovative recycling technologies and circular economy principles. Within this context, salt slag recycling through the synthesis of zeolite offers a valuable opportunity to contribute to these goals by addressing critical raw material challenges and minimising waste.

The following chapter will focus on the role of zeolite, specifically within the Z-ONA4LIFE project, in advancing circular economy practices. As such, this work aligns directly with EU policies aimed at promoting sustainable resource use and fostering innovation in recycling technologies.

8. https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/temas/economia-circular/estrategia.html
9. https://asturiascircular.es
10. https://www.ihobe.eus/economia-circular
11. https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/planes-y-estrategias/planes-y-programas.html

Zeolite in Focus:
Advancing Circular Economy Practices

Within the industrial sector, zeolite is considered a crucial class of inorganic materials due to its diverse potential applications. These employments span technical, environmental, industrial, commercial, agricultural, cracking and alkylation processes, as well as biomedical applications.

This versatility is given by the zeolite's porous nature and its ion-exchange properties. Zeolites serve as chemical sensors in industrial process control, environmental mitigation efforts (including heavy metals removal and gas capture), and applications such as indoor air quality and medical monitoring. As a consequence, they have gained increased attention in both research and industrial domains.

The utilisation of industrial waste as a raw material for zeolite synthesis holds environmental significance. Indeed, zeolites find extensive use across various technological applications, including environmental engineering (e.g., water treatment and softening), as catalysts and molecular sieve materials, for the removal of radioactive contaminants, in gas cleaning, in biotechnology and biomedical applications, and in petrochemical processes.

The impact of Z-ONA4LIFE

Research into the application of zeolite in industrial settings has demonstrated its significant benefits. This is the core focus of Z-ONA4LIFE, a project funded by the LIFE programme, which aims to showcase, on a pilot scale, the practicality and cost-effectiveness of producing synthetic Z-ONA zeolite from salt slag. This process aims to develop technology that enables the use of these materials as raw inputs, allowing them to be diverted from waste management pathways, including hazardous waste streams, and promoting circularity within aluminum foundries. The project's goal is to establish an almost waste-free process by recovering valuable by-products and recycling process water.

By the end of its 4-year duration, Z-ONA4LIFE will develop a business strategy to introduce its innovative zeolite across Europe, starting with implementation in Spain. This strategy aims to elevate the recyclability of aluminium in Europe while simultaneously reducing environmental, transportation, and industrial costs.

Zeolite in Focus: Advancing Circular Economy Practices: workshop outcomes

On the 21st of May the Z-ONA4LIFE project hosted a closed workshop exploring the potential of zeolite production in fostering a circular economy. This workshop brought together experts from various disciplines to share insights and collaborate on shaping the future of zeolite utilisation in Spain.

The main goal of the workshop was to facilitate interaction and knowledge exchange among experts within the framework of the Z-ONA4LIFE project. It aimed to achieve this by providing participants with an understanding of the project's objectives and innovative processes for producing synthetic Z-ONA zeolite.

The event focused on the Spanish market, as the main goal of the project is to launch the synthetic zeolite firstly in Spain and, subsequently, in the rest of Europe.

The selected stakeholder group, comprising 15 industry experts, provided its expertise in three main areas:

- Research and Development: Participants shared their expertise on optimising the Z-ONA zeolite production process and explored avenues for further research.
- Policy and Regulations: Discussions aimed to identify potential gaps or roadblocks that might hinder wider zeolite utilisation and brainstorm strategies for policy development that encourages a more circular economy.
- Industry Perspectives: This exchange helped identify potential applications for Z-ONA zeolite and explored the challenges and opportunities associated with its integration into existing industrial processes.

During the workshop, the experts provided useful insights on the adoption of synthetic zeolite in Spain. These contributions helped refine the questions for an open consultation, launched in July 2024, aimed at gathering feedback at European level to further validate and expand upon the insights collected.

The feedback provided is summarised below:

- Increase cooperation between research and industry by creating educational programmes;
- While zeolite is currently used primarily for environmental remediation, agriculture, water purification, catalysis and detergency, in the future it could be more widely adopted in other sectors, such as construction or energy;
- Concerns over the potentially lower quality of the Secondary Raw Materials (SRMs) may discourage their adoption;
- Regional policies need to be aligned with European ones to increase the adoption of SRM;
- Policies should provide fiscal and financial incentives to increase the use of SRMs.

Open Consultation:

Call for input for shaping the future of the zeolite industry

Following the organisation of the workshop, insights were gathered and analysed to understand the current adoption state of the art, current industrial and financial barriers and relevant policy gaps to formulate recommendations.

Zeolite adoption in industrial context

Respondents declaring to utilise zeolites in an industrial context (almost two thirds of our sample - see Figure 1), reported over 41% utilisation in catalysis, over 16% in effluent depuration, 8% agriculture and a variegated set of other uses, mainly focused on environmental remediation and aquaculture (see Figure 2 below).

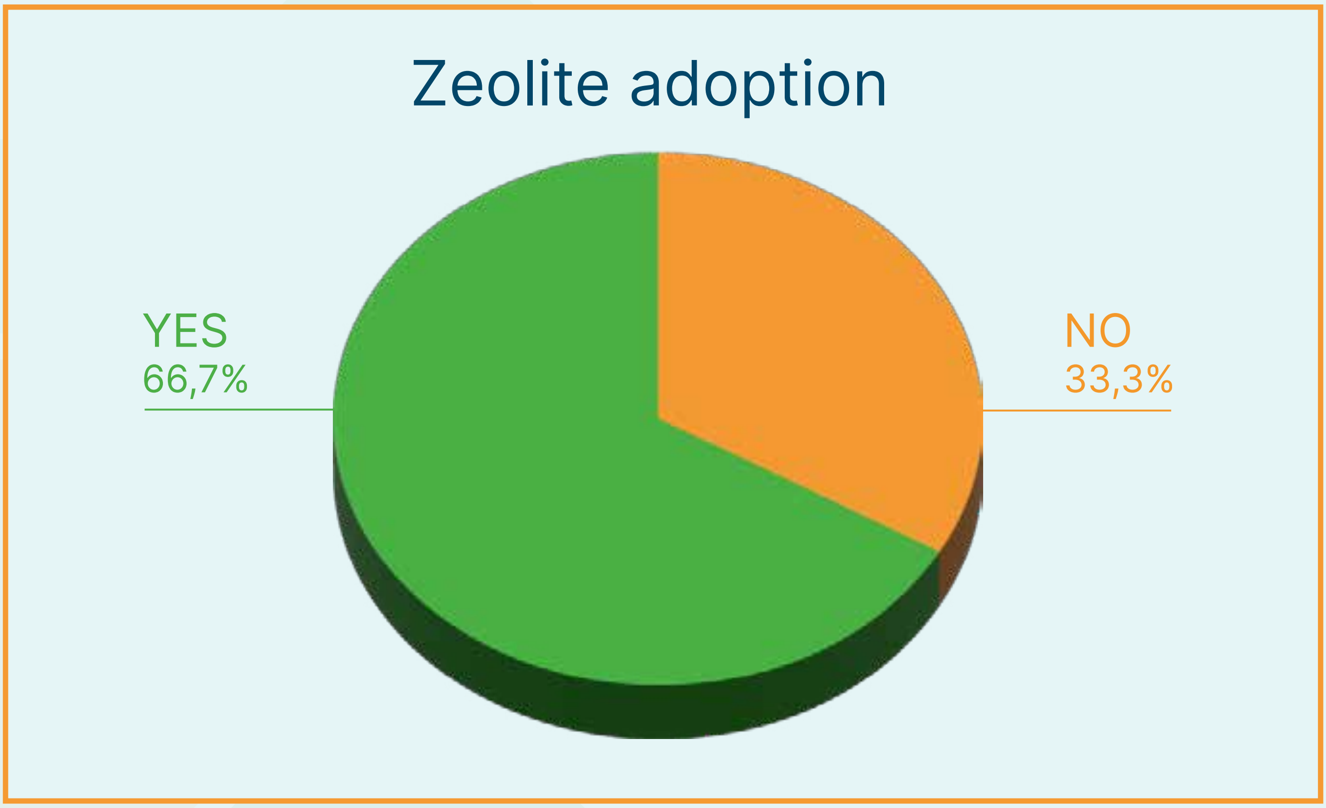


Figure 1. Industrial zeolite adoptions – sample size N= 15

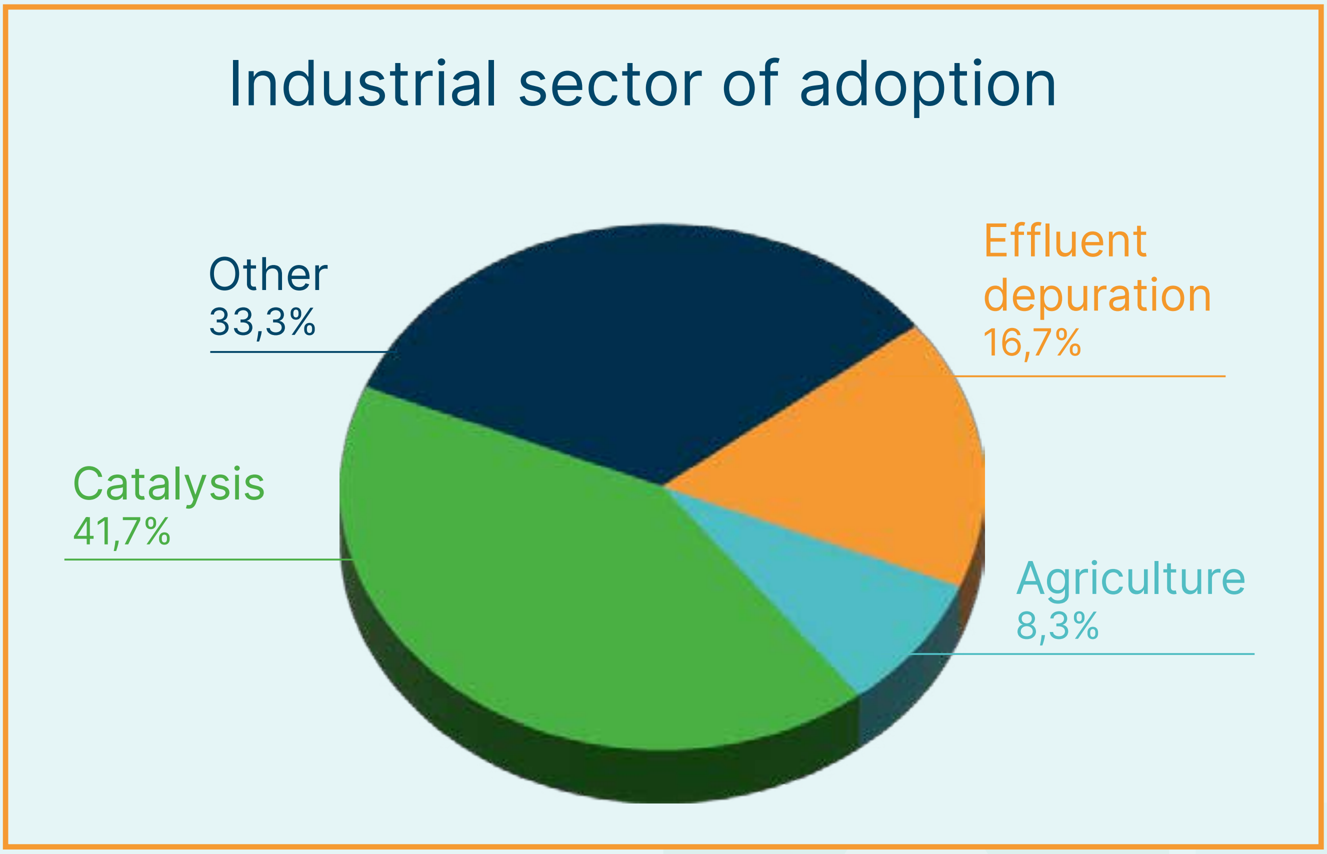


Figure 2. Industrial sector of adoption – sample size N= 11

Analysing responses in-depth, respondents underscored how Zeolites are widely used in various industrial applications due to their microporous structure, ion-exchange capabilities, and catalytic properties.

In one instance, zeolites have been synthesised in the metallurgical sector from industrial waste and employed as a base for metal oxide catalysts in processes such as pyrolysis and gasification of biomass and different types of waste. Additionally, they are utilised in ethylbenzene production, catalytic pyrolysis of plastics, and selective oxidation reactions. Specific catalytic applications include their use in shape-selective Fischer-Tropsch chemistry and in reactions like the Beckmann rearrangement.

Zeolites are also industrially exploited in environmental remediation, particularly in the treatment of contaminated soils and agriculture, where they serve to enhance soil quality by adsorbing harmful compounds and releasing nutrients gradually. Similarly, zeolites have been used in water treatment for the removal of nitrogen compounds and heavy metals, making them effective in purifying wastewater from industrial processes.

In the agricultural sector, zeolites are also instrumental in the production of sustainable biofuels, valorising agro-industrial waste for environmental remediation and fuel production. Moreover, zeolites have been employed in agriculture to embed soluble fertilisers, which significantly reduce fertiliser use and the associated environmental impact.

Finally, other applications include plastic recycling, gas separation, and the remediation of water and soil contaminated by pharmaceuticals, volatile organic compounds (VOCs), and perfluoroalkyl substances (PFAS).

Recycled materials adoption

The role of recycled materials in zeolites production was also taken into account by the questionnaire, with over 66% of respondents answering that the utilisation of these materials could help significantly reduce production costs, while only 6% disagreeing and 27% unsure. One of the main reasons provided by respondents is that recycled materials, such as industrial by-products (e.g., fly ash, slag, or coal gangue), are often more economical than traditional raw materials like pure silica or alumina, which are costly and generate waste. Utilising these industrial wastes not only reduces raw material costs but also decreases waste disposal fees, making the process more economical. Additionally, recycling industrial by-products for zeolite synthesis can simplify the production process by reducing the need for extensive refinement, thereby saving energy and cutting down processing steps. Other respondents focused on the sustainability aspect of this approach, emphasising dual potential benefits: lower production costs and environmentally friendly waste management solutions. For instance, producing zeolites from low-cost materials like kaolin or fly ash has been shown to be economically viable. This method also contributes to waste reduction from other industries, turning hazardous or problematic waste into valuable materials for applications in water purification, agriculture, and animal feed. Although there is potential for cost savings, large volumes of waste materials are required for the process to be effective on an industrial scale.

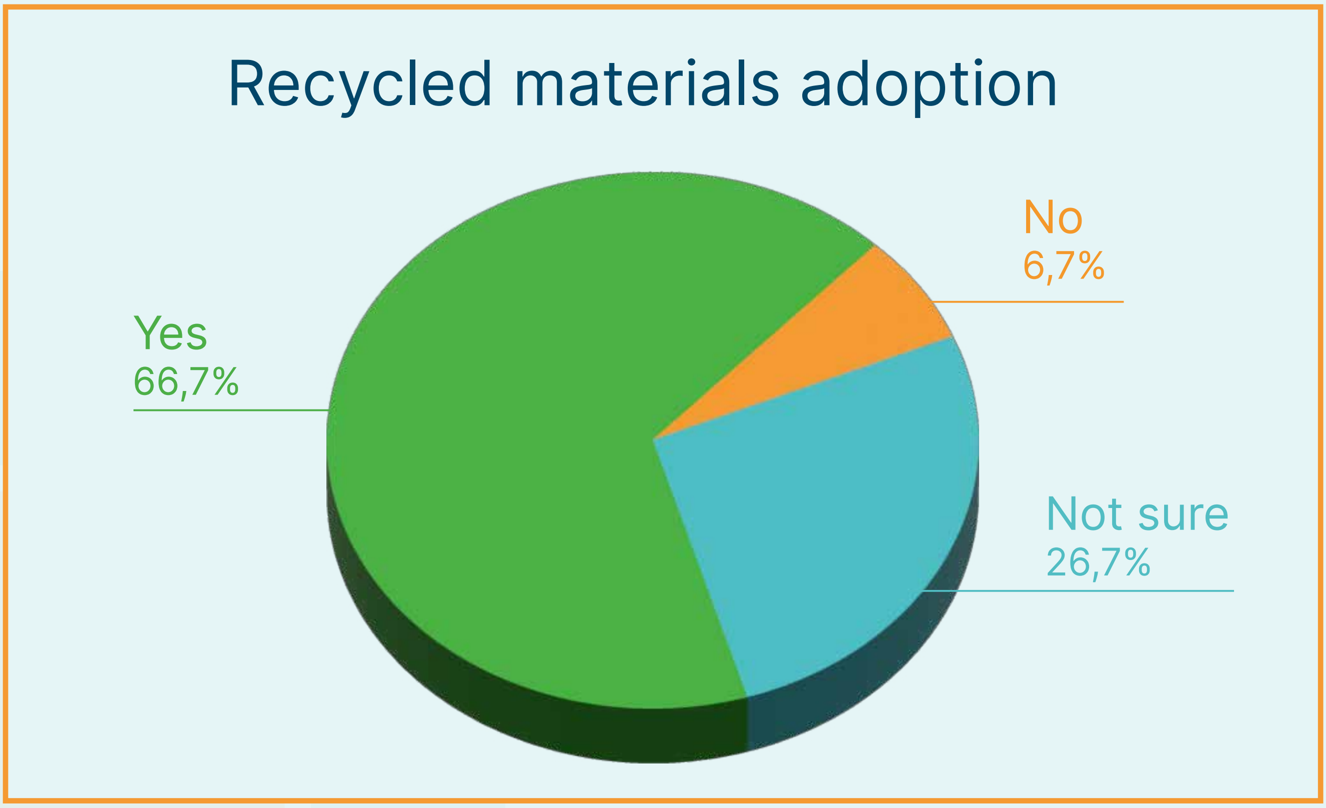


Figure 3. Recycled materials adoption – sample size N= 15

In terms of the industrial impact of recycled materials in the zeolite production chain, responses were rather mixed with over 26% denying comprising impact to the quality of zeolites and the same amount confirming such concerns. The remaining 46% declared themselves unsure. The motivations expressed to justify such concerns included, first of all, challenges primarily due to the impurities and variability in the composition of the feedstock. Impurities in recycled materials, such as metals or organic compounds, can negatively affect the chemical and physical properties of the resulting zeolites, potentially compromising their performance. Inconsistencies in the composition of recycled materials from one batch to another can lead to variations in the final product, making it difficult to ensure the quality and uniformity of the zeolites. This is particularly problematic in applications where precise structural properties are critical, such as in catalysis or molecular sieving.

Moreover, certain impurities, such as chloride formation during the synthesis process, could impact the adsorption capacity of the zeolite, especially in specific applications like water treatment. While the use of recycled materials could reduce raw material costs and promote sustainability, it is essential to carefully evaluate the effectiveness of these zeolites compared to those made from pure raw materials. Proper quality control and pre-treatment of the feedstock are crucial to mitigating the effects of impurities. In some cases, novel applications could be identified where impurities do not hinder the performance of the zeolites, or even where they could be beneficial. However, the success of this approach depends largely on the selection of homogeneous, high-quality waste materials that are available in sufficient quantities to justify their industrial use.

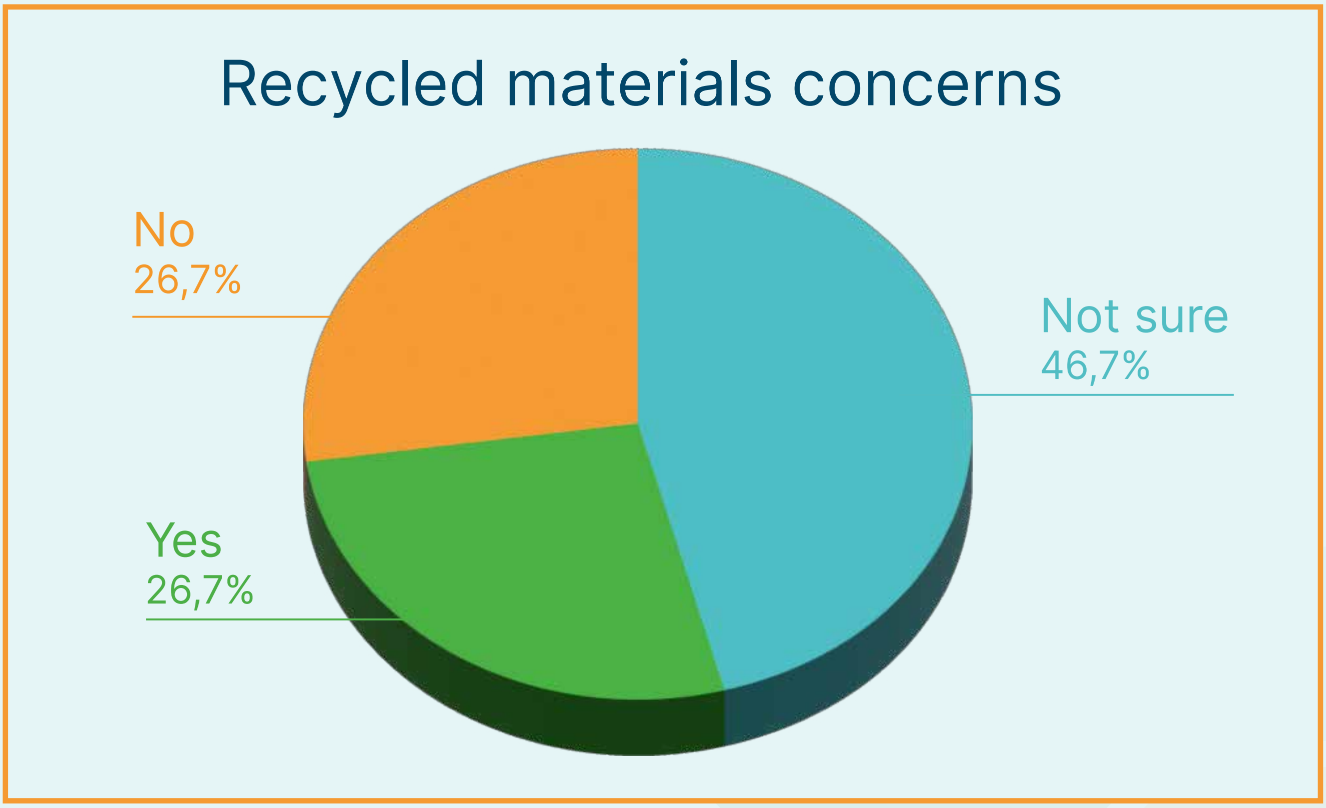


Figure 4. Recycled materials concerns – sample size N= 15

Industrial barriers

In terms of industrial barriers that producers or distributors might encounter in the expansion of the zeolite market, most respondents agreed that these are mostly the high costs associated with the production of synthetic zeolite. This issue is primarily driven by non-European producers offering lower prices for their products, which creates strong competition, despite the fact that NaOH remains an essential component for zeolite synthesis, whether using chemical reagents or secondary raw materials. Concurrently, other reasons were also indicated. These include first of all regulatory compliance with stringent EU regulations, such as REACH, which can be costly and time-consuming, requiring manufacturers to ensure that their processes meet strict chemical safety standards. Ensuring that these zeolites meet high-quality standards for various applications also involves rigorous testing and certification processes. Market acceptance was also indicated as a potential barrier, as products made from waste often face scepticism regarding their quality and reliability, necessitating extensive marketing efforts and performance demonstrations. Additionally, sourcing consistent, high-quality waste materials can pose supply chain challenges, as variability in the composition of these materials can affect the final product's quality. Moreover, it was observed that although the utilisation of waste materials can reduce raw material costs, the initial investment in the necessary processing technology and infrastructure can be high, and compliance costs can impact overall economic viability. Lastly, protecting intellectual property rights for innovative methods of synthesising zeolites from waste was deemed crucial, as safeguarding these innovations through patents is essential for maintaining a competitive advantage.

Successful applications and circular economy best practices

In terms of most successful application instances of zeolites, collected responses showcased how zeolites have become essential in a variety of industrial applications, thanks to properties such as ion exchange, adsorption, and catalytic activity. In environmental remediation, zeolites have been demonstrated to effectively remove heavy metals like lead and cadmium from wastewater and contaminated soils, as in mining wastewater treatment and soil reclamation projects. In agriculture, they improve soil quality by enhancing water retention and nutrient release, often used as carriers for slow-release fertilisers, particularly in paddy fields to increase crop yields. For water purification, zeolite-based filtration systems are applied to eliminate contaminants such as ammonia and heavy metals, ensuring clean drinking water in municipal plants. In the petrochemical industry, zeolites play a key role as catalysts in processes like fluid catalytic cracking (FCC), optimising fuel production. Additionally, they are used in air purification systems to capture volatile organic compounds (VOCs), thus improving air quality in industrial settings.

In terms of circular economy best practices, almost 40% of respondents declare to have used recycling practices, while about 23% either reuse or reduce used materials. However, only about 7% declares to have adopted new circular business models to their industrial applications.

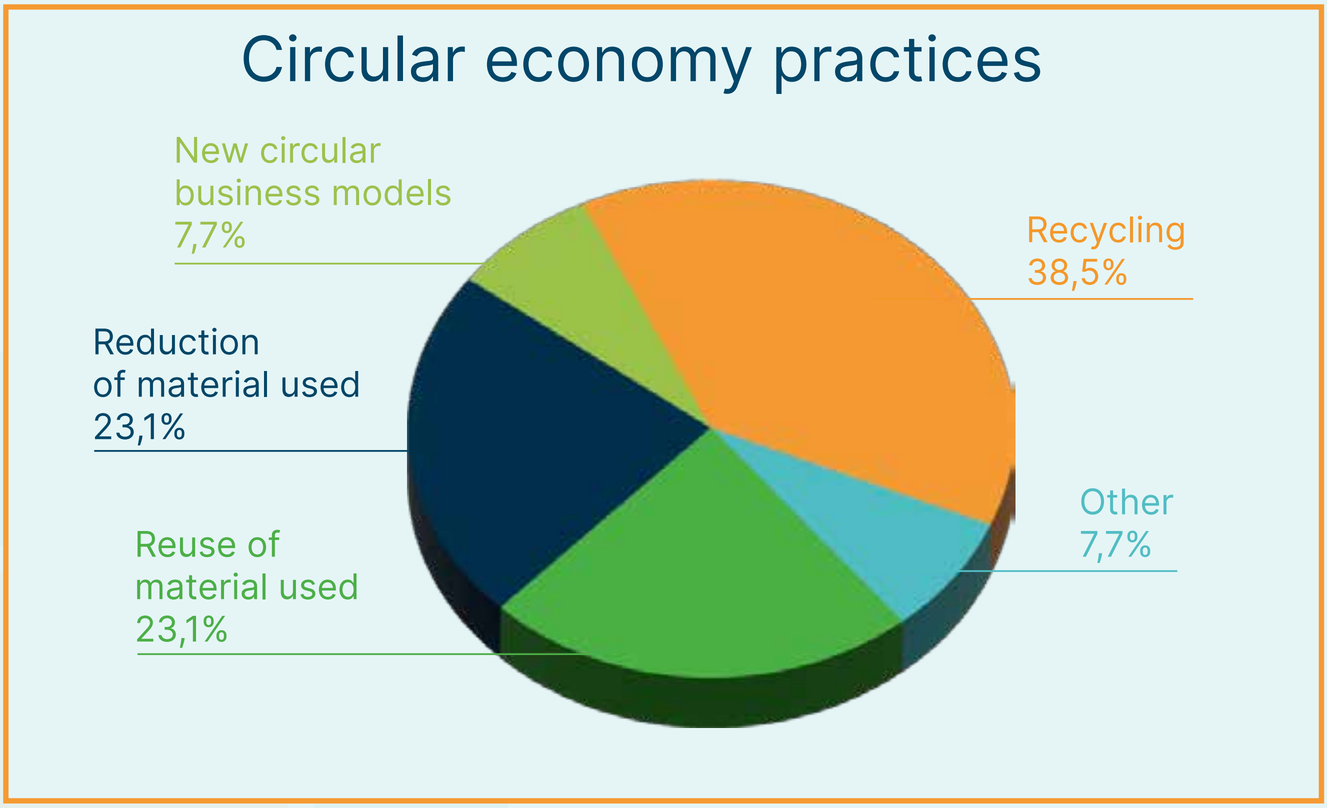


Figure 5. Circular economy best practices – sample size N= 10

Knowledge dissemination and capacity-building

Knowledge dissemination and capacity-building programs have been deemed essential for promoting the uptake of zeolite technologies across various industries by bridging the gap between scientific research and practical applications. These programs can foster networks and partnerships between academia, industry, and research organisations to drive innovation and knowledge sharing. Respondents also demonstrated that offering training, educational materials, and webinars helps industry stakeholders, such as manufacturers and engineers, better understand the applications and benefits of zeolites in fields like environmental remediation, agriculture, and water purification. Additionally, outreach campaigns can create informed market demand by raising awareness of the environmental and economic benefits of zeolites, which, in turn, encourages broader industry adoption. Building technical capacity through hands-on pilot projects, demonstrations, and technical assistance ensures that businesses can overcome practical challenges, while collaborative research and development projects advance the technology further. This holistic approach significantly increases the likelihood of widespread adoption of zeolite technologies in diverse sectors.

European new policies and existing frameworks

When asked about what should focus on news policies encouraging the incorporation of sustainable raw materials in industrial processes, responses point at the need to create a mixed approach combining incentives, standards, and support systems. Financial incentives such as tax credits, subsidies, and grants can be offered to companies that incorporate sustainable materials, thereby reducing the economic burden of transitioning from conventional materials. Establishing mandatory sustainability standards and certification programs can ensure that industries adhere to best practices while creating a market for verified sustainable products. Support for research and development, including funding and public-private partnerships, can drive innovation in sustainable material technologies and help bridge the gap between concept and commercialization. Additionally, educational programmes and public awareness campaigns can inform both industry stakeholders and consumers about the benefits of sustainable materials, driving demand and fostering a culture of sustainability. By creating a robust framework that includes regulatory compliance, economic incentives, and educational support, these policies can effectively facilitate the integration of sustainable raw materials into industrial processes.

In terms of existing frameworks potentially facilitating the utilisation of industrial zeolite at industry-level, the EU's Circular Economy Action Plan is seen as the leading one, with over 60% of respondents indicating it as the most functional one. This is followed by the European Green Deal (over 15%) and the Waste Framework Directive and EU Standardisation strategy with less than 10%.

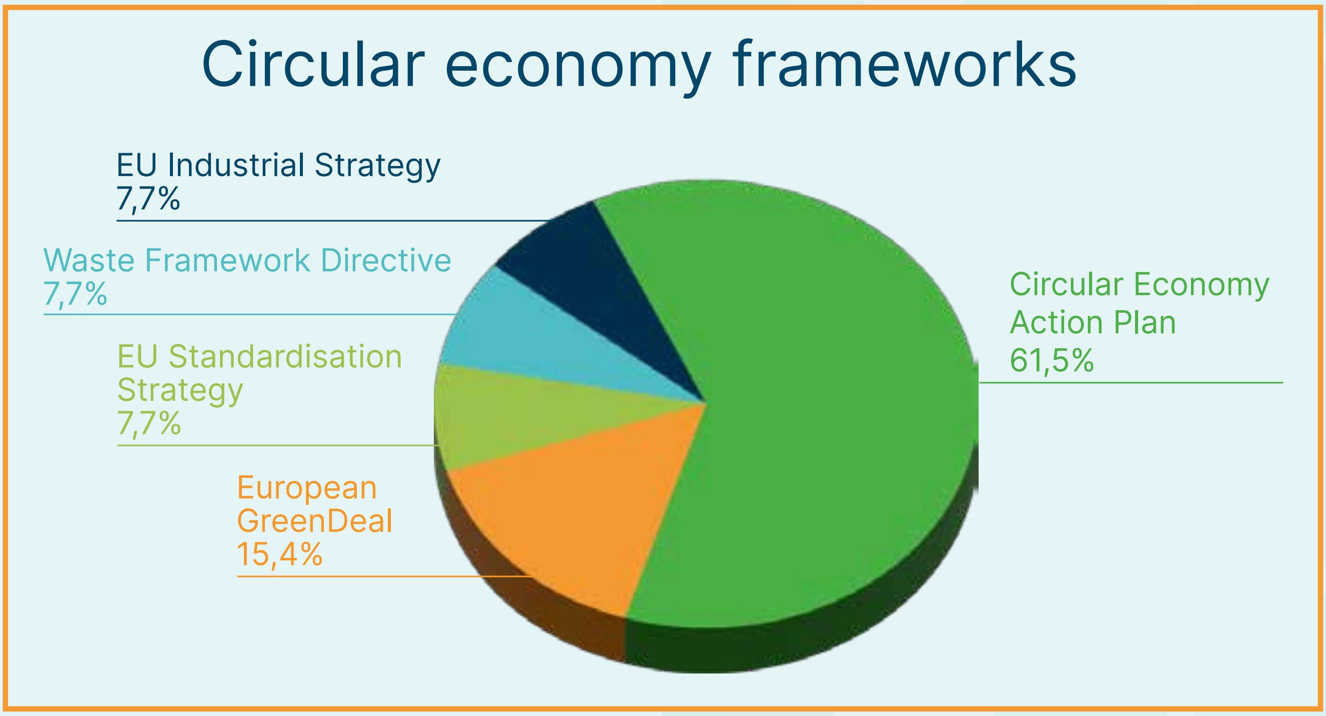


Figure 5. Circular economy frameworks – sample size N= 13

Proposed initiatives

In terms of suggested initiatives needed to increase awareness and understanding of zeolites among industry stakeholders, responses proposed several initiatives, each targeting different aspects of education, collaboration, and market positioning. One suggested approach is the development of educational programs, including workshops, seminars, and webinars tailored for industry professionals, researchers, and policymakers. These events can provide a foundational understanding of waste-based zeolite technologies, their benefits, and applications across sectors. Additionally, offering online courses and technical publications would ensure that knowledge is accessible to a broader audience, including global stakeholders.

Another proposal involves industry collaborations, particularly through public-private partnerships, which can foster innovation and allow real-world demonstrations of waste-based zeolite applications via pilot projects. Documenting successful applications and providing case studies of zeolite use in various industries (such as environmental remediation, catalysis, or agriculture) can further highlight the practicality and benefits of zeolites.

Marketing and communication efforts are also deemed useful for raising awareness, with suggestions for targeted marketing campaigns, social media outreach, and technical articles in reputable journals. These efforts can help shift market perceptions and emphasise the advantages of zeolites over traditional materials, such as their environmental benefits in line with sustainability initiatives like carbon footprint reduction and their role in the circular economy.

Regulatory support and policy advocacy are considered other key areas, as they can encourage the adoption of waste-based zeolites by promoting favourable policies, tax incentives, and certifications. Standardisation in the production and application of waste-based zeolites would help build trust and ensure consistent quality, making zeolites more appealing to industries.

Lastly, knowledge-sharing platforms are deemed relevant for fostering ongoing engagement between academia, industry, and government bodies. These platforms can facilitate the dissemination of technical information, best practices, and research findings, ensuring that stakeholders stay informed and can collaborate effectively. Some stakeholders also noted that competitive pricing and demonstrating superior performance in real-world scenarios would be critical to driving the adoption of waste-based zeolites, especially when competing against other established materials like activated carbon.

Zeolite future adoption outlook per industrial sector

Respondents' estimation of the future adoption rates of zeolites shows variability across various industrial sectors. Based on the average marks, effluent depuration (8.7) and agriculture (8.6) are identified as the sectors with the highest potential for adopting zeolite technologies in the future. This likely reflects the significant advantages zeolites offer in water purification, nutrient management, and soil quality improvement, aligning with sustainability goals and environmental regulations. Gas separation (8.0) also shows a high potential for zeolite adoption, which aligns with the established use of zeolites in processes like oxygen production and the purification of industrial gases. Other sectors with relatively strong prospects include soil remediation (7.7) and oil and gas (7.6), where zeolites are already used for catalytic processes, pollution control, and environmental cleanup efforts. In contrast, sectors like construction (6.6) and detergency (5.8) demonstrate moderate to low future adoption potential. This might suggest that while zeolites have niche applications in these areas, such as lightweight aggregates in construction or detergent water softeners, their growth may be limited by competing materials or technologies. Biomedicine (5.0) ranks the lowest, likely due to the more specialised requirements of medical applications, where regulatory challenges or specific material needs may constrain the use of zeolites.

Industrial sector	Average mark
Effluent depuration	8.7
Agriculture	8.6
Gas separation	8.0
Soil remediation	7.7
Oil and gas	7.6
Renewable energy	7.5
Construction	6.6
Detergency	5.8
Biomedicine	5.0

Table 1. Estimated zeolites future adoption rates per industrial sector – sample size N= 15

Identified gaps and timeline for implementation

Following the analysis conducted, the team has identified gaps to be addressed in the next few years, with recommendations at European level.

The timeline for implementation is based on the Z-ONA4LIFE partners' experience and insights gathered from interviews conducted during dedicated events.

Industrial gaps and recommendations

Gap	Recommendation	Impact to EU policy	Timeline for implementation
Cost barriers and uncertainties regarding the integration of waste-based zeolites into existing supply chains	Definition of a standard and certification setting for sustainable use of materials that could lower the costs of adopting zeolites	EU Chemical Strategy EU Industry Strategy EU Standardisation Strategy Circular Economy Action Plan	Mid term 2 years
Lack of sufficient data or case studies demonstrating the economic viability of waste-based zeolite applications in specific industries	Establish collaborative platforms where industries that are early adopters of waste-based zeolite can share best practices, data, and lessons learned	EU Chemical Strategy EU Industry Strategy EU Standardisation Strategy Waste Framework Directive Circular Economy Action Plan	Long term 5 years
Limited awareness of emerging markets and applications for zeolite use	Feasibility studies to demonstrate zeolites' practicality and benefits in emerging markets	EU Industry Strategy Circular Economy Action Plan	Long term 6 years

Policy gaps and recommendations

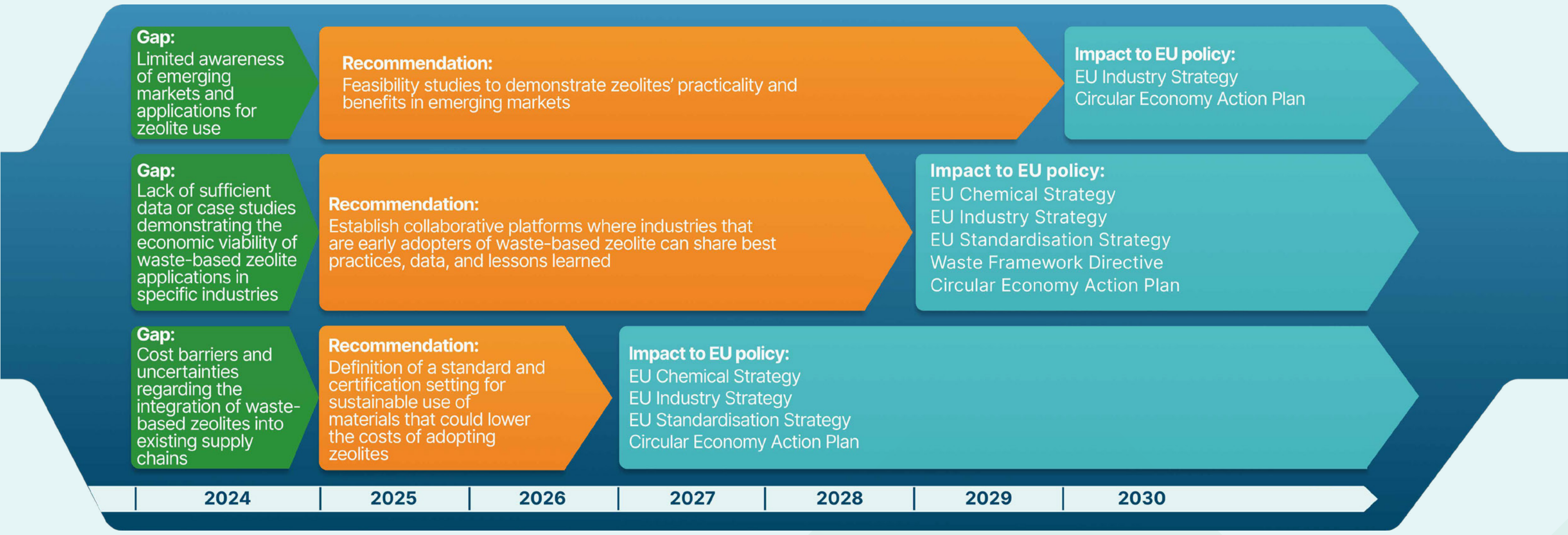
Gap	Recommendation	Impact to EU policy	Timeline for implementation
Misalignment between local and European policies in terms of circular economy practices	Establish a continuous feedback loop between local and European governing bodies with regular reviews and consultations	Circular Economy Action Plan Waste and Contaminated Soils Law National Programme for the Prevention of Waste	Long term 6 years
Addressing market absorption and competitiveness of secondary raw materials	Implement government policies that support the use of secondary raw materials, such as tax incentives for companies that use recycled materials, subsidies for recycling programs, or regulatory frameworks that mandate a certain percentage of recycled content in products.	Circular Economy Action Plan Waste and Contaminated Soils Law National Programme for the Prevention of Waste	Long term 6 years

Educational gaps and recommendations

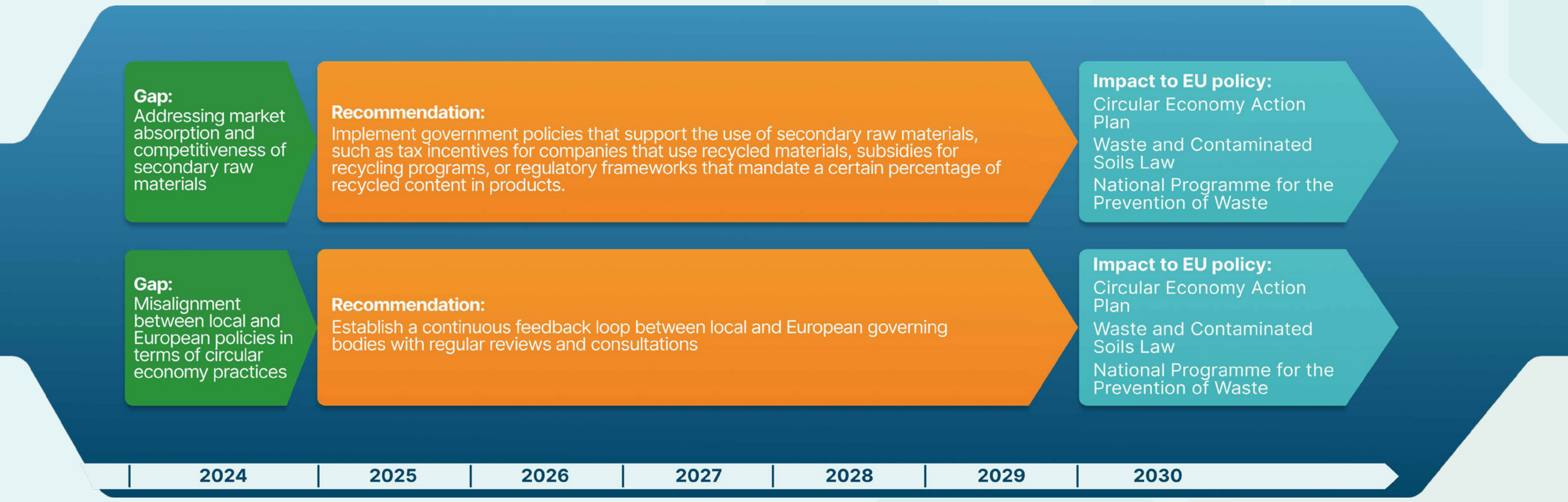
Gap	Recommendation	Impact to EU policy	Timeline for implementation
Lack of skills to adopt synthetic waste-based zeolite in industry	Involvement of industrial players in collaborative projects and pilot trials and scale-up initiatives	Waste Framework Directive Chemicals Strategy for Sustainability	Mid term 2 years
Low exchange of best practices between industry and academia	Development of • New university courses with the integration of zeolite studies • Industry Workshops and Seminars • Online Learning Platforms (Webinars, Online Courses and Resource Libraries) • Internships and Externships • Certification Programmes	EU Chemical Strategy EU Industry Strategy EU Standardisation Strategy Waste Framework Directive Circular Economy Action Plan	Mid term 3 years
Limited awareness of the potential applications of zeolites in emerging fields	Organise cross-sector awareness workshops to educate industries about potential applications and share emerging opportunities.	Circular Economy Action Plan Chemicals Strategy for Sustainability EU Chemical Strategy EU Industry Strategy EU Standardisation Strategy	Short term 1 year

The recommended actions are also graphically represented in the timelines below:

Industrial gaps and recommendations



Policy gaps and recommendations



Educational gaps and recommendations

Gap	Recommendation	Impact to EU policy
Gap: Limited awareness of the potential applications of zeolites in emerging fields	**Recommendation:** Organise cross-sector awareness workshops to educate industries about potential applications and share emerging opportunities.	**Impact to EU policy:** Circular Economy Action Plan; Chemicals Strategy for Sustainability; EU Chemical Strategy; EU Industry Strategy; EU Standardisation Strategy
Gap: Low exchange of best practices between industry and academia	**Recommendation:** Development of New university courses with the integration of zeolite studies; Industry Workshops and Seminars; Online Learning Platforms (Webinars, Online Courses and Resource Libraries); Internships and Externships; Certification Programmes	**Impact to EU policy:** Circular Economy Action Plan; Chemicals Strategy for Sustainability; EU Chemical Strategy; EU Industry Strategy; EU Standardisation Strategy
Gap: Lack of skills to adopt synthetic waste-based zeolite in industry	**Recommendation:** Involvement of industrial players in collaborative projects and pilot trials and scale-up initiatives	**Impact to EU policy:** Waste Framework Directive; Chemicals Strategy for Sustainability

2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030

The Z-ONA4LIFE consortium

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Z-ONA4LIFE is on a mission to showcase that the synthesis of Z-ONA zeolite is not just a technical and economic accomplishment but a transformative solution for optimising the recycling of aluminium salt slag and Si-rich wastes. Our primary objective is to elevate the circularity of aluminium foundries through groundbreaking pilot-scale production that not only repurposes these wastes but also pioneers a near-zero-waste process.

Would you like to cooperate with us, discover the main advancements of our work?

Then, feel free to get in touch with us!

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